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A PHOTOELECTRIC DECIMAL-CODED SHAFT DIGITIZER

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SUMMARY – This paper describes a non-counting decimal-coded shaft digitizer. Phototubes are used to read the posi-of masks, permitting static as well as dynamic readout with minimum loading of the measured shaft. Reading is done with several units, each reading a digit of the decimal number representing the shaft position. A special decimal code employing 5 phototubes per decade is used to avoid intra-decade ambiguities. Inter-decade ambiguities are prevented by using two masks on all but the first decade. An experimental digitizer, using standard components, is described.

INTRODUCTION

In recent years there has been increasing need for shaft digitizers in the field of measuring, control, and computing mechanisms. The requirements for these digitizers vary considerably in range, resolution, loading, shaft speed at readout, readout rate, and numbering system. This article describes a new shaft digitizer developed to meet the following requirements:

1. Resolution: 1/100 revolution
2. Range: $10^n - 1$, where n is any desired integer
3. Shaft speed at readout: 0 to ± 1000 counts / sec.
4. Load on measured shaft: Bearing friction only
5. Time between readouts: 1 second
6. Numbering system: Decimal.

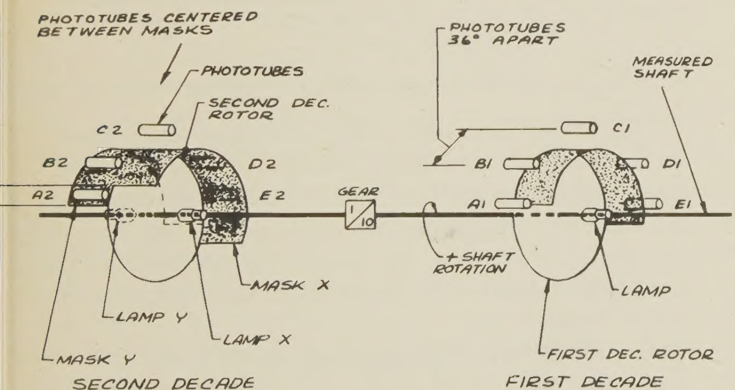


Fig. 1 – Simplified sketch, first and second decade configuration.

The digitizer described in the following sections operates by "reading" a coded representation of a given shaft position rather than by counting from a reference position to that shaft position. The former method results in a simpler device and one that is not susceptible to problems of cumulative error, as is often the case for the latter method.

PRINCIPLES OF OPERATION

The Photoelectric Decimal-Coded Shaft Digitizer consists, in essence, of several similar reading units, each unit reading one of the digits of the decimal number equivalent to the shaft position. Thus the first unit reads, say, tenths of revolutions; the second unit, geared 1 to 10, reads revolutions, and so on. We shall describe the operation of the first two of these units, the units decade and the tens decade. All higher decades operate in a manner similar to the tens decade.

Fig. 1 shows the configuration of the first decade. Five photocells with defining slits are equally spaced 36^o apart on an arc. A simple 180^o mask is attached to the shaft so that it may rotate between the photocells and a lamp. As the shaft rotates, and if the lamp is flashed at appropriate times, the 5 phototubes will be illuminated in succession and obscured in succession. One, and only one, phototube will change its conductance state every 36^o. An unambiguous (synoptic) decimal code, as shown in Fig. 2, may be formed from these changes. The second decade has its rotor geared 1 to 10 to the input shaft. For this rotor to be identical to the first decade rotor, and to insure that the second decade digital readings change exactly (and only)

SHAFT ANGLE IN DEGREES	PHOTOTUBE CODE ABCDE	DECIMAL VALUE
306+ to 342-	00000	9
342+ to 18-	+0000	0
18+ to 54-	++000	1
54+ to 90-	+++00	2
90+ to 126-	++++0	3
126+ to 162-	+++++	4
162+ to 198-	0++++	5
198+ to 234-	00+++	6
234+ to 270-	000++	7
270+ to 306-	0000+	8

Fig. 2. Photoelectric Decimal-Coded Shaft Digitizer

at angles corresponding to the first decade changes between 9 and 0, the slit widths and electrical and mechanical tolerances would have to be zero. Any tolerance or slit width greater than zero would result in small equivocal transition angles where a second decade phototube would receive light when the corresponding first decade phototube was obscured, or vice versa.

These equivocal angles would result, for example, in a reading of 39 or 20 at angles between those readings 29 and 30.

This difficulty is eliminated and a synoptic relationship between successive decades is assured in the following manner. The second decade is provided with two masks and two lamps as shown in Fig. 1. The masks are identical except for an 18° displacement between them. The masks are oriented so that when the first decade count is at the transition point between 9 and 0, the edge of mask X is 9° ahead of the center of a second decade phototube slit and the edge of mask Y is 9° behind the same phototube slit. Large tolerances can be permitted with, say, 18° first decade slits. The second decade slits must be less than 18° by an angle equal to the sum of the tolerances. The resulting configuration is such that the second decade phototube in question does or does not receive light depending upon which lamp and mask set is used. The choice of lamp is made by the first decade A_1 phototube. When this phototube is illuminated (during counts 5 thru 9), the second decade leading lamp and mask set is used. When the A_1 phototube is obscured (during counts 0 thru 4), the lagging lamp and mask set is used.

Consider the effects of this arrangement in the case of the shaft being in the position shown in Fig. 1. The first decade mask is in a position such that phototube A_1 is half obscured and the other phototubes are completely obscured. Thus the first decade reading is either 0 or 9, depending on whether or not the A_1 circuits regard half-illumination as a suitable signal. The second decade masks are in positions such that both of them obscure phototubes $B_2C_2D_2$, and E_2. However, A_2 will be illuminated if mask X is used, and obscured if mask Y is used. The decade will read either 0 or 9, depending on whether lamp X or Y is used, which, from the above considerations, depends on whether or not phototube A_1 receives a signal. Thus the second decade reads 0 if the first decade reads 0, and 9 if the first decade reads 9.

As the shaft is rotated clockwise, the readings would progress from 00 to 04 with mask X still in use. Then the first decade count changes to 5, and as it goes thru 9, mask Y is selected. For these angles the second decade count is still 0, as mask Y has rotated to positions which illuminate A_2 only, and the total count progresses to 09. When the shaft is turned further, the first decade reads 0 again, mask X is selected again, both A_2 and B_2 can receive light and the value read out shifts from 09 to 10. The mode of operation for other angles is similar.

The description of system operation to this point has been essentially that of reading out with the shaft at rest. Further refinements are necessary in order to read out dynamically at high angular velocities. These refinements are necessary because of the delay encountered in the process of choosing the proper second decade lamp. During this delay time (T_d) and at maximum speed (W_m), the second decade shaft rotates through an angle $\theta_d = W_m \times T_d$. To prevent errors, when reading out at shaft speeds between $+W_m$ and $-W_m$, it is necessary to reduce the second decade phototube apertures by an angle equal to $2\theta_d$ minus $2\theta_t$, a further reduction to compensate for mechanical and electrical tolerances. The maximum readout rate will be a function of the delay time as well as the response time of lamps, phototubes, etc.

It has been shown that the result obtained by using the proper one of the two lamp-mask sets in the second decade, was the synoptic operation of the first and second decades. Viewed in another manner, the actual rotation of the 2nd decade rotor has been converted to an effective rotation consisting of smooth movements separated by jumps alternately forward and backward in angle. These jumps, ordered by the first decade are such that all equivocal angles are omitted. Fig. 3 shows this effective rotation versus actual rotation.

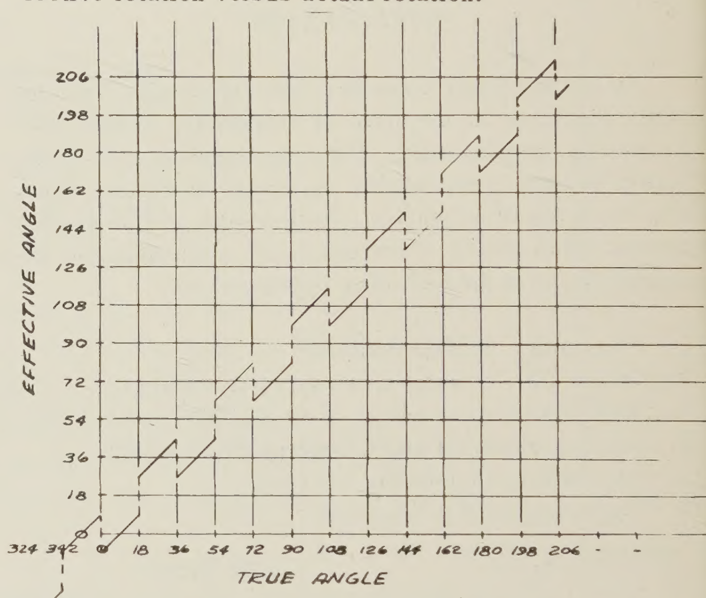


Fig. 3 – Second decade, effective angle versus true angle.

It is evident that the principles described can be applied to the design of the higher decades. A third decade could be made physically identical to the second. Digitizing tens of revolutions, it would be geared 1 to 10 to the second decade and its lamps would be controlled by the second decade A_2 phototube.

EXPERIMENTAL MODEL

An experimental digitizer was constructed to satisfy the requirements given in the introduction, and to determine component types and values for reliable operation.

Since the first decade must resolve 1/100 revolution (rather than 1/10 revolution as described in the previous section), a cylindrical rotor with ten symmetrically located 18 degree slots was used. The code for this units decade could be formed by spacing the 5 phototubes either 3.6° apart as shown in Fig. 4a, or 75.6°

$72^\circ + 3.6^\circ$) apart as in Fig. 4b. The latter configura-ion was the one actually employed, as it permits the use f a smaller rotor and larger phototubes than the former. For the second decade rotor, two 180° masks, with a lisplacement angle of 18° between them, was fixed on he same shaft as the first decade rotor. The second dec-ade resolves tenths of revolutions. In the first decade small lamps were used rather than 1 large lamp. A amp was placed opposite each phototube to provide sufficient light for the phototubes through the neces-sarily small defining slits. These slits were made 1.5° wide (1/32 inch on a 2.3 inch diameter) to insure the resolution of 1/100 of a revolution. In the second decade 2 groups of 3 small lamps, rather than 2 large lamps, were found to provide enough light for the 5 phototubes through their defining slits. As indicated previously,

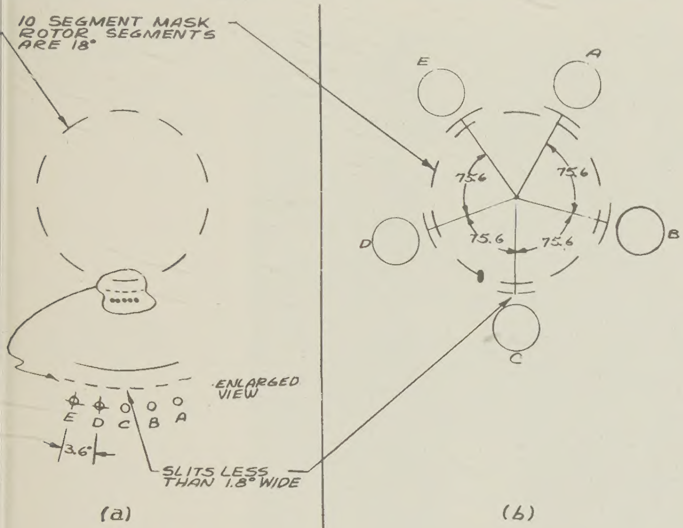


Fig. 4 – First decade, possible configurations to resolve 1/100 revolution.

the second decade slit width is restricted as follows, $\theta_s = 18^\circ - 2\theta_D - 2\theta_t$, where the delay angle $\theta_D = W_M \times T_D$, and θ_t is the total tolerance. The delay time was set at less than 0.75 millisecond, making the delay angle 2.7° at W_M = 10 RPS and the mechanical tolerance allowed was ± 0.9°. Therefore the slit widths had to be less than 18 – 5.4 – 1.8 or less than 10.8°. These second decade slits were set at 9°, allowing a safety factor of ±0.9° or ±0.25 milliseconds.

It was found that standard G.E. AR-4 argon glow lamps served as very satisfactory light sources when used with ultra-violet sensitive 5583 phototubes. The lamps were operated with short duty cycle pulses of greater than 10 times rated dc current. Life tests performed on a group of lamps revealed little deterioration of light output and no failures for the equivalent of one year of operation at 1 flash per second, 40 hours a week. When not obscured, the phototubes developed signal pulses of 3 microamps. An amplifier (½ 12AY7) was used with each phototube to obtain signal pulses of better than 50 volts at an impedance level of about 15K ohms. In addition to the lamps, phototubes, and amplifiers, the digitizer chassis contained 2D21 thyratrons for flashing the lamps.

Equipment for storing the value readout was placed on a separate chassis. Five thyratrons and 5 relays per decade were used to convert from the synoptic code pulses to decimal digits in the form of contact closures. Since the thyratrons were biased to -15 volts, the 50 volt signal pulses were greater than 3 times the amplitude needed to insure operation. This safety factor permitted considerable variation in lamp, phototube, amplifier, and thyratron characteristics without danger of the digitizer malfunctioning.

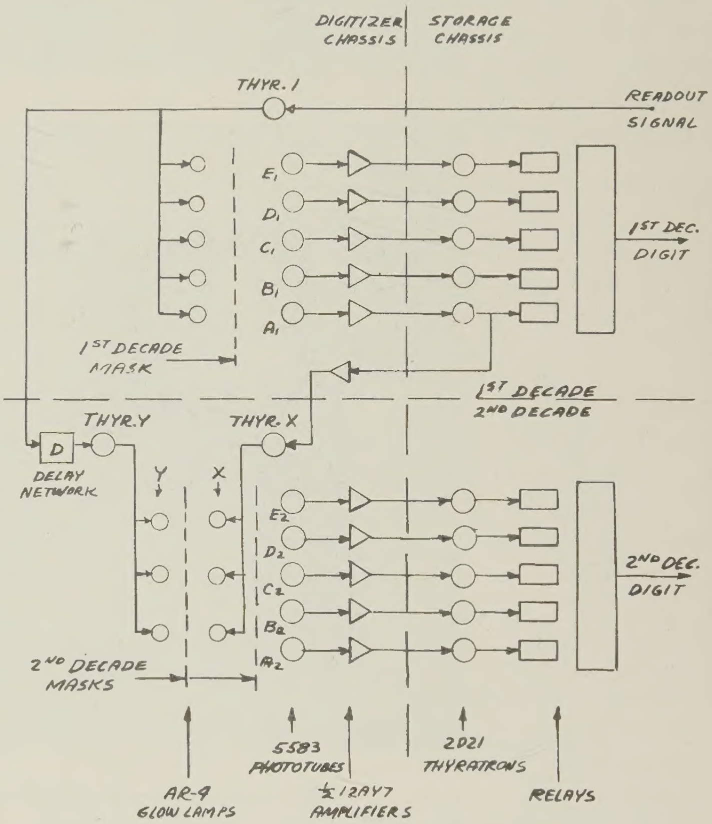
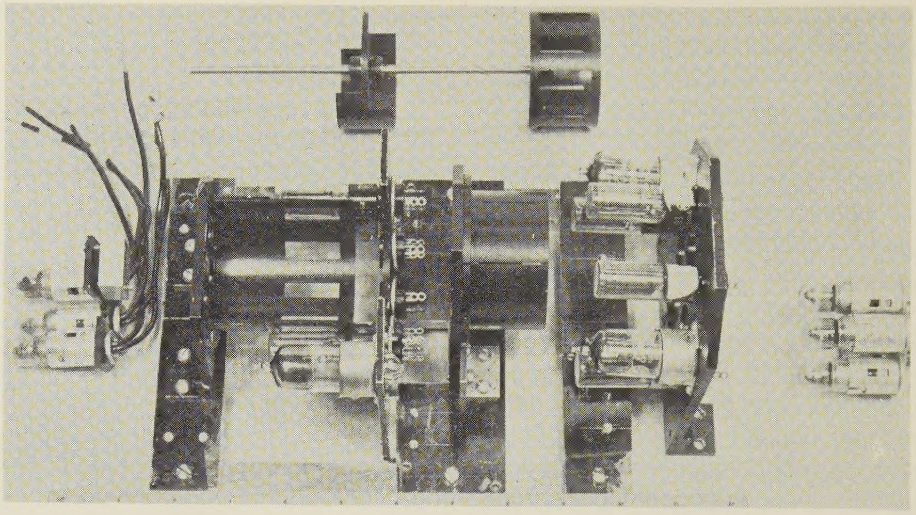


Fig. 5 – Block diagram, two decade experimental model.

The sequence of operation can be followed most easily by referring to the block diagram of Fig. 5. The external readout signal triggers thyratron 1 which flashes the first decade lamps. Depending on the shaft position, a number (0 to 5) of the first decade phototubes receive light. The resulting signals are amplified, stored in the thyratrons and relays and converted to a decimal digit by the relays. If phototube A_1 receives a signal, thyratron X is triggered, flashing lamps X. If A_1 does not receive a signal, the readout signal, delayed in network D fires thyratron Y, which flashes lamps Y. Thyratrons X and Y derive their plate voltage from a common capacitor so that if the former fires, the latter cannot fire.

The second decade signals are amplified, stored, and converted to a decimal digit in the second decade relays.



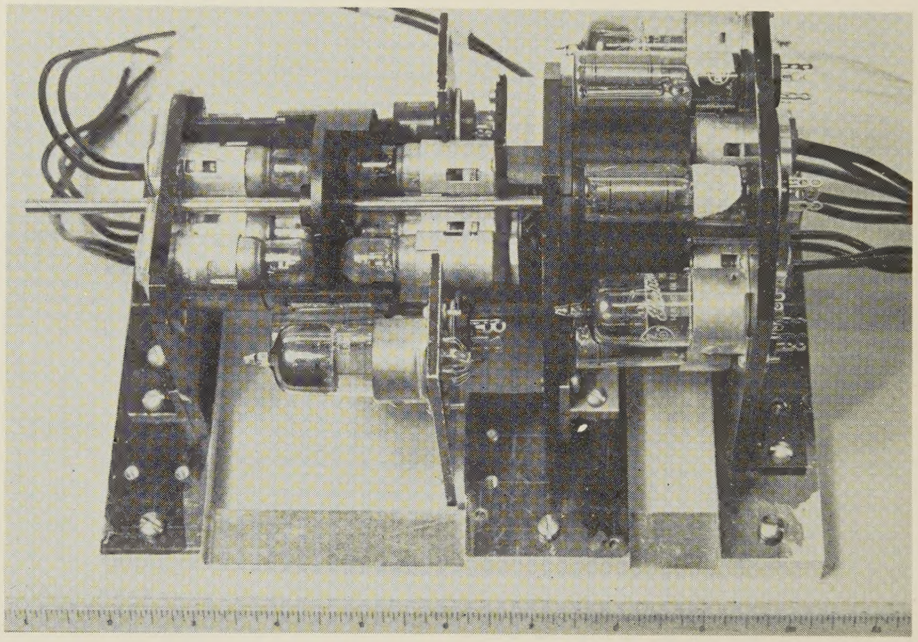


Fig. 6 – Experimental model, components partially assembled.

Fig.6a is a photo showing the lamps, rotors, etc. partially assembled. Fig.6b shows the components assembled on the digitizer chassis. In both photographs, the first decade components are on the right, the second decade components on the left.

Both static and dynamic tests of the digitizer gave satisfactory results. The fact that several thousand consecutive numbers were read out of the digitizer with no errors was an indication of the reliability of the machine.

CONCLUSION

It has been shown that a reliable dynamic shaft digitizer may be constructed by using phototubes and simple cylindrical masks to encode shaft position. The code used is such that ambiguities are avoided and precision mechanical or electrical components are not required.

For this particular machine, a decimal code was used. The principles described here can be used for the design of digitizers employing other than decimal notation. The preliminary design has been made for a similar digitizer employing an octal code for simple conversion to binary numbers.

ACKNOWLEDGEMENT

The authors wish to express their gratitude to D. Rutland and D. Pitman, both of the Benson-Lehner Corporation, for fundamental concepts and contributions which led to the development of the Shaft Digitizer.

The Photoelectric Decimal-Coded Shaft Digitizer was developed under Contract DA-04-495-ORD-163 which is under the technical supervision of the Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland. Any inquiries regarding technical aspects of this equipment should be addressed to the Ballistic Research Laboratories.

AN ANALOG-TO-DIGITAL CONVERTER

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SUMMARY – A shaft position to binary number converter uitable for use as an input device for a digital computer is escribed. The basic component of the converter is a binary echanical revolution counter having an output in the form of oltages or pulses on parallel lines representing, in the inary number system, the quantity stored in the counter. mbiguities are eliminated by a novel method of internal witching. The effects of backlash are discussed and shown o be negligible.

INTRODUCTION

There are a number of important applications of diital computing techniques which require that a quantity aving a basically analog representation be expressed as binary number. The device herein described is capble of performing this function when the quantity in

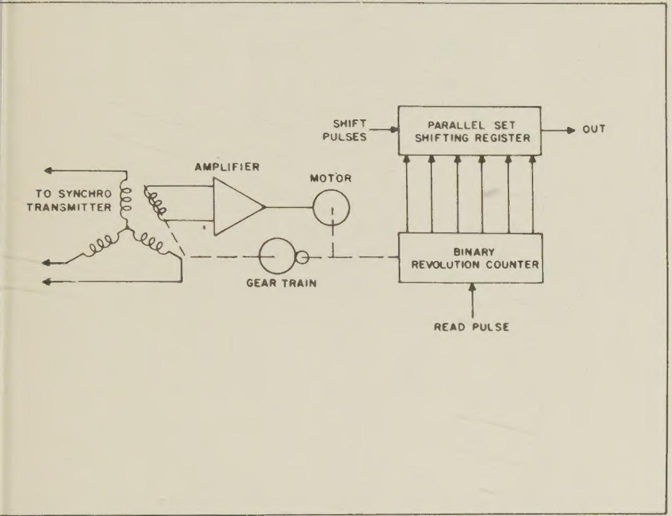

Fig. 1 – Block diagram of analog-to-digital converter.

uestion is a shaft position representing, for example, n angle between zero and 360 degrees. It will be asumed that the angular position of the shaft changes at relatively low rate (1 rpm) when accurate readings are equired, and that the shaft is capable of driving a synhro-control transformer. Fig. 1 is a block diagram of a evice that has been used to perform the conversion. We ee that it consists of a standard synchro-controlled, haft-positioning servomechanism so arranged that the evolutions of the motor shaft are counted by a mechanical evolution counter operating in the binary number system. he ratio of the precision gear train is such that the ounter goes from zero to full capacity during precisely ne revolution of the synchro, and thus every position f the synchro corresponds to a given binary number tored in the revolution counter. The numerical contents f the counter are available, upon the application of a ead pulse, as a pattern of pulses on parallel lines corresponding to the ones and zeros of the binary number stored in the counter. This pulse pattern is used to set a shifting register whose contents may be shifted into the computer when shift pulses are applied.

A SIMPLIFIED COUNTER

The heart of this conversion system is the binary revolution counter which will now be described in detail. First, consider Fig. 2, which represents perhaps the simplest scheme which might occur to one who is designing such a counter. Each digit of the counter con-

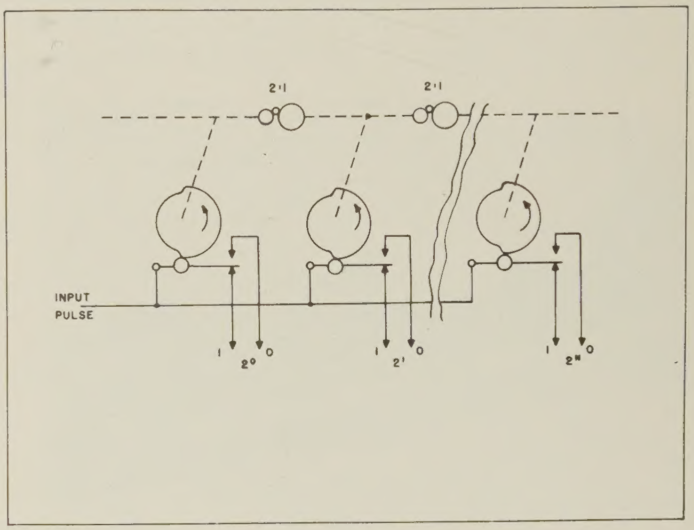

Fig. 2. Mechanical counter (simplified).

sists of a cam-operated switch. When the switch is in the UP position, the corresponding digit is a zero, and when the switch is DOWN, the corresponding digit is a one. The cams are driven by a gear train with a 2:1 reduction between successive stages. As Fig. 2 shows, every half revolution of the 2^0 cam in the direction of the arrow results in an increase of one in the number contained in the counter.

As Fig. 2 is drawn, every digit of the counter output would be a one, representing the full capacity of the counter; and an additional half-turn of the 2^0 cam would cause every digit of the output to become zero. This additional half-turn will result in a rotation of the last cam of only $1/2^{n+1}$ revolution, which for a 12-stage counter amounts to 1/8192 revolution. To adjust the switch to operate during such a small rotation would be

difficult enough; but the situation is further aggravated by the fact that to avoid gross errors as the counter changes from all *ones* to all *zeros*, every switch must operate at exactly the same time. The net effect of these difficulties is that it is impossible to construct a satisfactory counter of this simple type.

THE MECHANICAL REVOLUTION COUNTER

One type of binary revolution counter designed to overcome the difficulties of this simple type depends for its operation on the use of two switches per cam, spaced 90° apart. Since the cam has a 180° lobe, it is impossible for both of the switches to operate simultaneously; and by always reading the switch that is not in the process of changing, it is impossible to eliminate all ambiguities. This is accomplished automatically by employing the configuration of switches representing the digits of less significance than the kth to determine which of the switches on cam k should be read.

The operation of the counter can best be explained by an example. As the counter is shown in Fig. 3A, the output of each stage is a *one*. A small rotation of the input cam in the direction of the arrow, sufficient to cause switch *S*-O to operate, will cause the output of every stage to become a *zero* without any of the other switches operating.

If the input shaft is rotated through approximately 180° in the direction of the arrow, the configuration will be that of Fig. 3B. During this rotation, the second cam turns through 90°, the third cam through 45°, etc. With switch *S*-O in the *L*-position, the counter output is still all *zeros;* but a small additional rotation of the input shaft, sufficient to cause switch *S*-O to change to the *H*-position will cause a *one* to appear in the first digit. There will be no other change in the counter output due to the new position of cam 2.

It will be noted that switch 2-*B* is ambiguous, but this can have no effect on the output of the counter because the position of the previous cam guarantees that voltage can be applied only to switch 2-*A*. Study of the

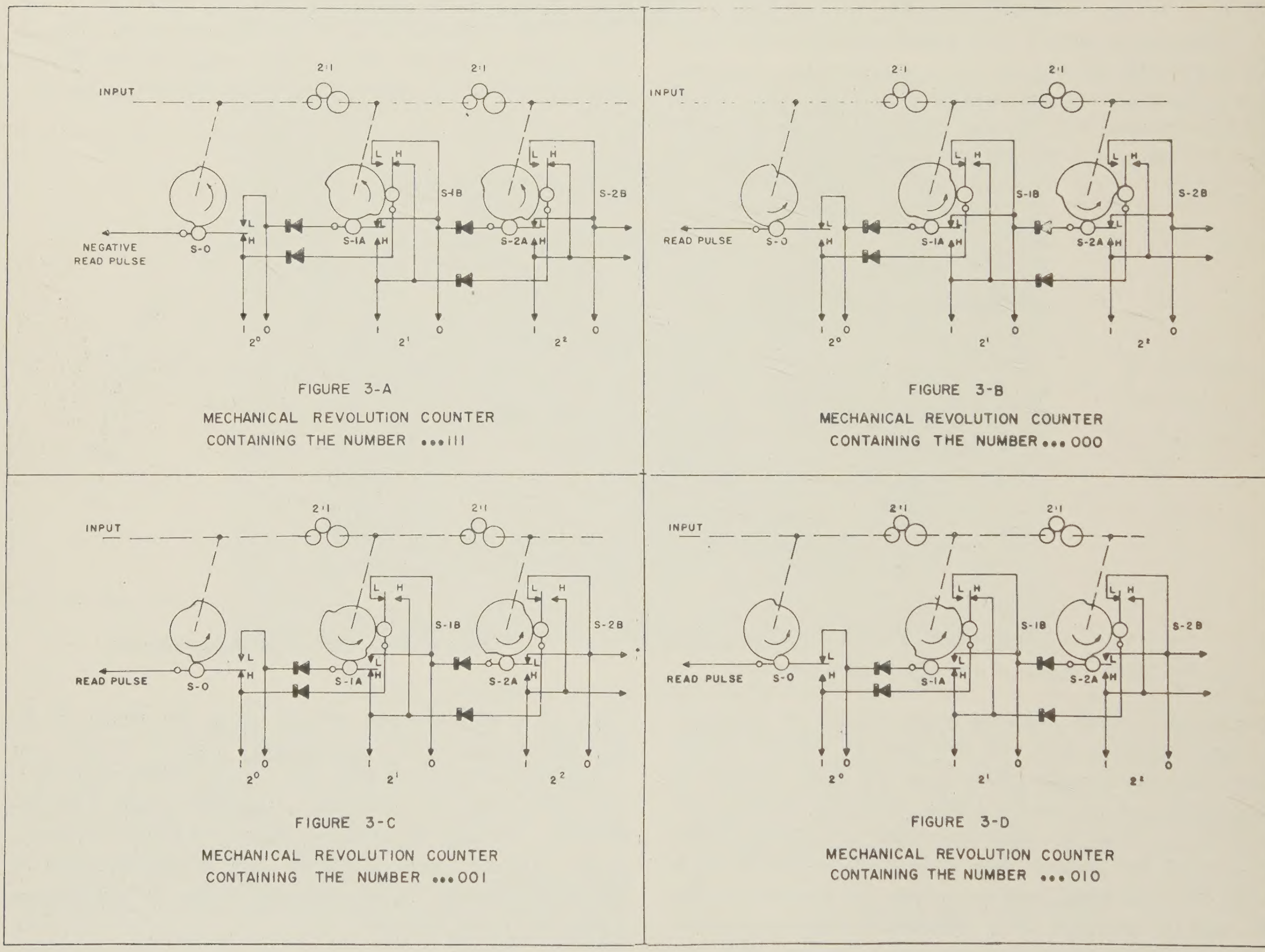

FIGURE 3-A
MECHANICAL REVOLUTION COUNTER
CONTAINING THE NUMBER •••111

FIGURE 3-B
MECHANICAL REVOLUTION COUNTER
CONTAINING THE NUMBER •••000

FIGURE 3-C
MECHANICAL REVOLUTION COUNTER
CONTAINING THE NUMBER •••001

FIGURE 3-D
MECHANICAL REVOLUTION COUNTER
CONTAINING THE NUMBER •••010

circuit will show that when any switch (with the exception of S-O) is ambiguous, both of the switches on the previous stage will be in the H-position or both of them will be in the L-position, and no input will be applied to the ambiguous switch. Because of this, operation of the ambiguous switch cannot effect the output of the counter.

If the input shaft is rotated through an additional 180° the configuration becomes that of Fig. 3C. As long as S-O remains in the H-position, there is no further change in the counter output; but when the switch changes to the L-position, the output of the first stage becomes a *zero* and the output of the second stage becomes a *one*. An additional 180° rotation brings the counter to the configuration of Fig. 3D. As before, there is no change in the output until the first switch operates, at which time the output of the first stage changes to a *one* with no other changes in the output of the counter. In this way, the operation of the counter can be traced as the input shaft is turned through any number of revolutions, and it will be seen that the output is a binary representation of the number of half-revolutions described by the input shaft, up to the full capacity of the counter.

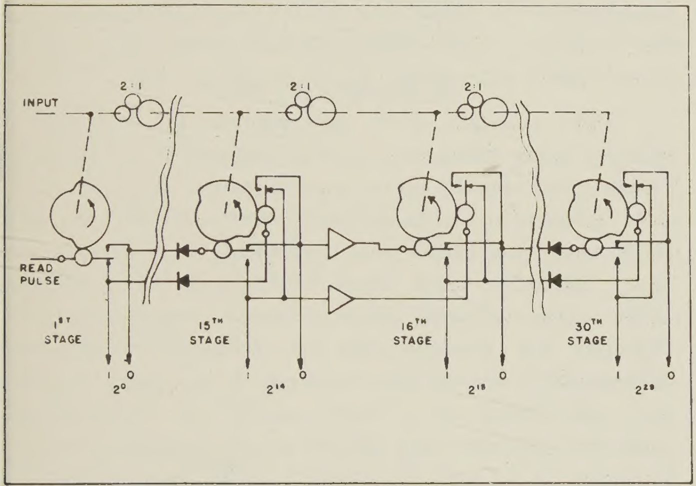

Fig. 4. 30-stage counter.

The function of the diodes is to prevent undesired short circuits when both switches of any stage are in the same position. Because transfer is accomplished solely by the action of switch S-O, the only ambiguity that might exist would occur if a reading were taken when that switch is in the process of changing. At that time, there is no output, either *one* or *zero*, from any stage. This condition can be detected automatically, and any reading taken at that time can be rejected. The switches used in the counter are snap action; therefore, in practice, the correct reading is nearly always available.

The effect of backlash can be ascertained by observing that the number contained in the computer will not change if the input shaft is locked and any individual cam is rotated as far as backlash will allow, provided this backlash does not approach 45°. This can be seen from the figures, since, in every case, either no switch changes or the switch that does change is not being used. If there is backlash between each pair of gears such that the larger gear can be turned through 0 degrees when the smaller gear is locked, then, if the first cam is locked, the second cam can be turned 0 degrees, the third cam through $(\theta + \theta/2)$ degrees and the *n*th cam through $(\theta + \theta/2 + \theta/4 + \ldots + \theta/2^{n-1})$ degrees. If there were an infinite number of stages, the last stage could be turned 20°. In any reasonable design, 20 is much less than 45°; so, when the device is used as a revolution counter, backlash has no effect and an unlimited number of stages is feasible. When the device is used to divide a circle, the precision of the auxiliary gear train is potentially a limiting factor since, in this case, the backlash which is important occurs when the low-speed end of the gear train is locked and the other end is turned. It is possible to use a precision gear train for the counter and thus combine the functions of the two gear trains. If this is done, the accuracy of the division

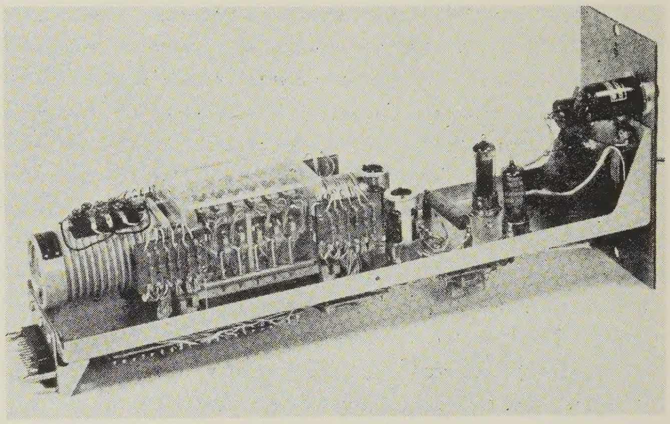

Fig. 5. Photograph of the analog-to-digital converter.

may be limited by the accuracy of the counter gear train, but other factors, such as the transmission accuracy of the synchro system, may also limit the accuracy of the conversion.

Although there is no practical limit to the number of stages which may be used in a revolution counter of this type, the cumulative forward resistance of the diodes in series may necessitate the inclusion of pulse amplifiers in a counter of more than approximately fifteen stages. For example, a thirty-stage counter, having a capacity of 2^{31}, or 2,147,483,648, would be perfectly practicable, using the configuration of Fig. 4.

If sharp pulses are used to read the counter, the cross talk due to stray capacitances may become intolerable. This difficulty may be eliminated by inserting a low-pass filter at the counter input to remove high-frequency components from the reading pulse.

Fig. 5 is a photograph of an analog-to-digital converter of the type described here.

THE UNIVAC TUBE PROGRAM

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SUMMARY – This paper presents the history of the tube program evolved for the UNIVAC system. It shows that reliable performance of vacuum tubes in large scale computers can be achieved by an integrated program, starting with design and initial tube selection, and covering pre-installation process- and marginal checking. Performance data on four UNIVACS are used to illustrate the success of the program, with data on UNIVAC #1 covering 16,000 hours of operation.

INTRODUCTION

The reliable performance of vacuum tubes in the UNIVAC** system is the result of a program initiated at the very outset of computer design work. It was realized that a tube program covering all phases of design and also computer operation was necessary, since the known rates of tube failure, when applied to equipment on the scale of the UNIVAC, predicted short periods of trouble-free operation. The designers of the UNIVAC set out to solve this problem by developing a program embodying the following points: Selection of the best available group of tubes for computer use, design of circuits to accommodate normal variations from tube to tube and changes due to aging, incoming inspection of all tubes at points at or near where the tubes are to be operated, and comprehensive preventive maintenance or marginal checking in the field to minimize operational down-time caused by tube failure.

This paper deals with the approach used for the UNIVAC system for each of the points of the tube program and shows the final results in terms of tube performance.

SELECTION OF TUBE TYPES FOR THE UNIVAC SYSTEM.

The problem of selecting the best available tube types for the UNIVAC started with its design in 1948. The Eniac, which had been successfully completed in 1945, provided considerable experience with a large number of tubes in a single installation; however, little data pertinent to our problems was available from the tube manufacturers on newer tube types, and the manufacturers believed that it was not economically feasible to provide the necessary information.

Five-hundred-hour life tests were common in the tube industry, but virtually no life test information existed to indicate the type of performance which could be expected for 5,000, 10,000, or more hours. Also, emphasis was on the normal Class A type of operation, with cut-off and zero bias checks a rarity. It must be remembered, too, that this was at the very beginning of the "reliable tube" era, and that while many "computer" tubes exist today, only one did in 1948.

Tube manuals were investigated to determine a group of tubes which would meet the general requirements found in the circuits under consideration. Then all available information, manufacturers recommendations, and engineering estimates were combined to eliminate the least desirable tubes from the list. In this process, tubes which exhibited inherent design weaknesses were rejected. For example, the 6J6, a double triode, was eliminated for design shortcomings. In this tube the plate and grid structures of each section are opposite each other and symmetrically placed around a single cathode. A change in the cathode position would have an opposite effect on the plate current of each section under cut-off conditions, since the cathode would move away from one grid, while moving nearer the other grid. On the other hand, a double triode with separate structures would eliminate this possible source of trouble.

Some of the points which favored further consideration of a particular tube were: manufacturing controls nearer the characteristics of interest, whether or not the tube was included in JAN specifications and, in addition, the volume of production was considered, since popular tubes will be more reasonable in cost and more readily available. Quantities of the potentially satisfactory types were purchased, and their behavior under the proposed operating conditions was checked to determine the probable spread of characteristics. These initial data were analyzed, and the tubes which showed promise were placed on life test under the proposed operating conditions.

The 25L6 was picked as the chief UNIVAC tube for general high power, high speed use. For high power circuits, but where poorer cut-off characteristics could

* Formerly with Remington Rand Inc.
** Reg. U.S. Pat. Off.

be tolerated, the choice fell to the 28D7, a double tetrode, which allowed us to decrease the number of sockets in the computer. For certain gating operations, we selected the 7AK7, one of the first computer tubes, which had originally been designed for the Whirlwind Project at M.I.T. For IF amplifiers in the mercury delay line memory system, the 6AK5 and 6AN5 were selected. For low power gating in comparison circuits, the 6BE6 was selected, with the knowledge that a computer version was on the way in case it should be needed. There are a number of other tube types in the UNIVAC system.

Fig. 1 lists the quantities of the major tube types used which account for 5442 of the 5612 tubes in the system. The tube types which are not tabulated are used in very small quantities.

Fig. 1

Today, with the experience gained with the UNIVAC, we would evaluate additional points in a selection of tube type, but the basic approach of engineering estimate, characteristic tests, and, finally, life test would remain the same.

CIRCUIT DESIGN

Circuit design was forced to proceed before any long range life test data were available. However, early results gave a general guide and subsequent life tests showed that the margins of safety allowed would ensure long life. In general, a 50% decrease in zero-bias plate current from the new tube minimum was used as a lower design limit. Wherever possible the plate and screen dissipation was 50% of the manufacturer's nominal ratings. Also, extreme care was given to the consideration of such factors as grid current, heater-to-cathode leakage, and cut-off plate current.

Early tube experience in the computer presented a number of problems which had not been anticipated during the original tube selection and, consequently, had a bearing on the use of these tubes in computer circuits. The 25L6 was the first tube to present such a problem. Initial tests were performed on several lots of 100 tubes each. In later lots, larger quantities were checked, and the variation was considerably more than in earlier lots. For example, one test on the 25L6 was performed with 60 volts on the plate, 60 volts on the screen, and zero grid bias. Early results showed that a minimum plate current of 55 milliamperes could be expected. These first large lots showed that a lower limit of 49 milliamperes would be necessary to prevent large scale rejections. As mentioned previously, a large initial design safety factor had been allowed and this change in the acceptance limit was still within the anticipated range.

In another case, the 7AK7's exhibited a failure rate higher than was expected. The failures were traced to a circuit which, according to published characteristics and initial tests, would operate the tube within its screen dissipation limits. Excessive screen current would develop, however, and before long the screen would be operating above rated dissipation. The circuit was modified to lower the screen dissipation and no further large-scale trouble has been found. However, the 7AK7 has not had as long a life in UNIVAC #1 as that of some of the other types. Some reduction of life can be attributed to the damage, short of failure, which was caused by the early circuit condition.

During the first 500 hours of computer tube life, both the 25L6 and the 28D7 started giving reverse grid-current trouble. Grid currents as high as 100 microamperes or more were found. The problem was presented to the manufacturers, who by this time had become quite interested in our problem. A new type 25L6 specifically designed to eliminate this trouble by gold plating the grid was obtained and proved to be successful. Reverse grid-current problems were eliminated in the 28D7 by reducing the heater voltage from the rated 28V to approximately 25V. This reduction had no adverse effects on emission or other tube characteristics, since the tube is still space charge limited at 25 volts, while the cathode and envelope temperatures are lower, providing all around improvement in tube life. It is well to point out that the tube manual made no mention of the effect of reduced heater voltages on anything but power output and percent distortion, even though five pages were devoted to the tube. This is an excellent example of why tube manual data alone is seldom adequate.

The cases cited above show the type of problems which were encountered during design, construction and test of the first UNIVAC system. These problems were primarily tube problems and not troubles introduced by circuit design. Fortunately, a solution to these problems usually involved only slight changes.

INCOMING INSPECTION.

With the solution of minor tube problems in early hours of computer operation, the computer settled down to give results with a minimum of tube troubles. It was now our problem to ensure a continuing supply of tubes meeting UNIVAC requirements for future equipment production. Complete incoming inspection specifications were developed, and 100% inspection of all incoming tubes was rigorously followed. The tests performed during inspection included tests of the characteristics at the operating points corresponding to those actually used, particularly zero-bias and cut-off plate current. In addition, high speed or "tap" short-testing was adopted in certain cases. Equipment capable of detecting two megohm shorts for five micro-seconds or more was designed for this purpose. Tube rejection rates and quality levels were closely watched for any significant change in manufacturers' quality.

Further processing was required in the case of the 6AN5 and the 6AK5. It was found that some lots of tubes showed wildly erratic behavior during the first 200 or 300 hours of operation. A G_m slump of as much as 50% in 25 hours, with complete recovery in an additional 50 hours, was observed. In the case of the 6AN5, a burn-in time of 50 hours was established, and all tubes were aged under operating conditions before insertion into the UNIVAC. The 6AK5 was abandoned in favor of the 5591 when burn-in stabilization was found to be inadequate. In the case of the 5591, a burn-in time of 200 hours was adopted.

Also, a system of analyzing tube failures in computers was instituted in an attempt to determine preferred suppliers and to work with manufacturers to obtain even better tubes. As a result of this system, a modified 28D7 has been designed with improved characteristics at some increase in cost.

Incoming inspection is used, therefore, not only to find "weak" tubes, but also as a source of information for anticipating and correcting problems before tubes are installed in a computer.

PREVENTIVE MAINTENANCE AND MARGINAL CHECKING

If we have successfully solved the problems of selection, inspection and design, the tubes should give long trouble-free service. However, the life of a tube is finite and, therefore, failures will occur which cause down-time or the loss of valuable information. A preventive maintenance program was adopted to anticipate a large percentage of these tube failures.

Normal preventive maintenance consisted of a periodic test for all tubes for the pertinent characteristics. Test limits were established slightly above actual circuit failure points. The interval between maintenance periods was determined by the rate of deterioration of tube characteristics from the maintenance test limit to the circuit failure point. As an example of the usefulness of the maintenance program, about 80% of the tube failures in UNIVAC #1 for *16,000* DC hours of operation were detected during preventive maintenance periods. Failures usually detected in maintenance are low emission, poor-cut-off, high heater-to-cathode leakage, and "sleeping sickness". Failures occurring during machine operation or operational failures are usually open heaters and intermittent shorts.

Although the present system of preventive maintenance has definitely reduced computer down-time, we are now in a stage of investigating marginal checking techniques. In one system under consideration, problems are run through the computers at reduced heater voltages. Early reports indicate that this technique will be a much less costly process and will at the same time improve upon the percentage of detectable tube failures. In addition, tube socket connections are not broken in the system, thus reducing a source of intermittents. No long range data are available at this time on the overall effect of marginal checking.

TUBE PERFORMANCE IN THE UNIVAC

One measure of tube performance is the percentage of tubes remaining in service after extended periods of operation. In UNIVAC #1 about 3150 or over 80% of the

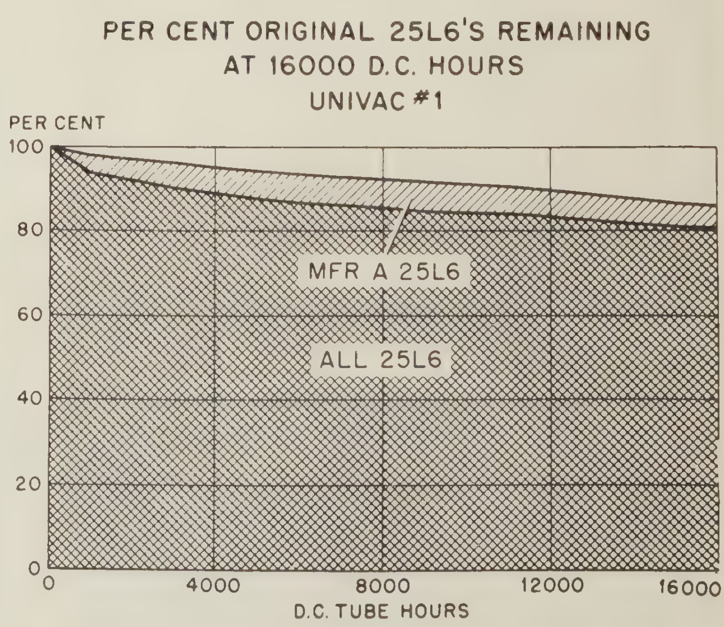

Fig. 2

25L6's originally plugged into the computer were still in use after 16,000 hours of DC operation. This is a failure rate of 1.34% per thousand hours. Four manufacturers' brands of 25L6's were used in UNIVAC #1, and Fig. 2 shows the percentage of original 25L6's remaining over this period for these four brands as a group, and also the percentage remaining for manufacturer "A". The significant difference of a particular manufacturer is apparent from this graph and this indicates that by proper screening of manufacturers, a reduction in the failure rate can be obtained. This fact has been recognized in subsequent UNIVACS which use 25L6's purchased from manufacturer "A" only. The survival of 80% of the tubes originally used after 16,000 hours would seem to be more than adequate justification for our program.

However, a better measure of the success of the UNIVAC tube program is the amount of computer down-time due to tube failures. As pointed out earlier, routine maintenance will generally detect failures of a particular type, so that computer down-time will be governed to a certain extent by the way in which tubes fail. Fig. 3 graphs the type of failures for the 25L6's originally used in UNIVAC #1 and this data shows that 67% of the

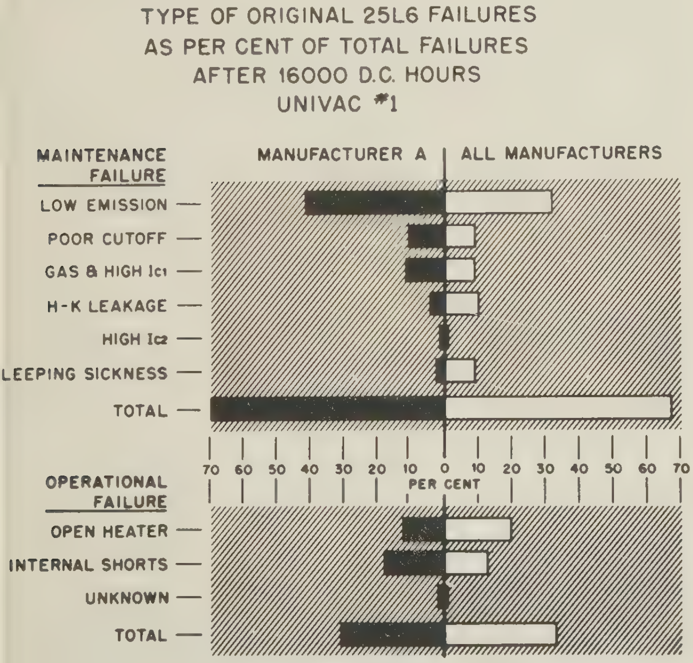

Fig. 3

failures were of the type which could have been detected by maintenance. In practice more than 80% of all tube failures were found during the maintenance period. One reason for this differential of 13% was that some heater burn-outs and internal shorts occurred during the tests in the maintenance tube checker.

The failure rate, and, as a result, computer down-time, has been significantly reduced in later UNIVACS. In Fig. 4 the rates of failures per thousand hours of all UNIVAC tube types are compared with the 25L6 in UNIVACS #1, #2, #3, and #4 covering the first 4,000 hours of DC operation. This graph shows that the failure rate in UNIVACS #3 or #4 is about one-seventh of the number for UNIVAC #1. If we assume that the ratio of failures to those caught by preventive maintenance in UNIVAC #4 is 80%, the same rate as experienced in UNIVAC #1, then the amount of down-time in later computers can be estimated. Fig. 4 shows a rate of 0.5% total failures per thousand DC hours of operation for UNIVAC #4. Using the assumption that 80% of the 0.5% failures will be found during maintenance, then only 0.1% of the tube failures will go undetected and cause down-time. This means that approximately six failures will occur every thousand DC hours. Since most installations are operated 160 hours per week, one can expect a failure to stop the computer through its check circuits about once a week.

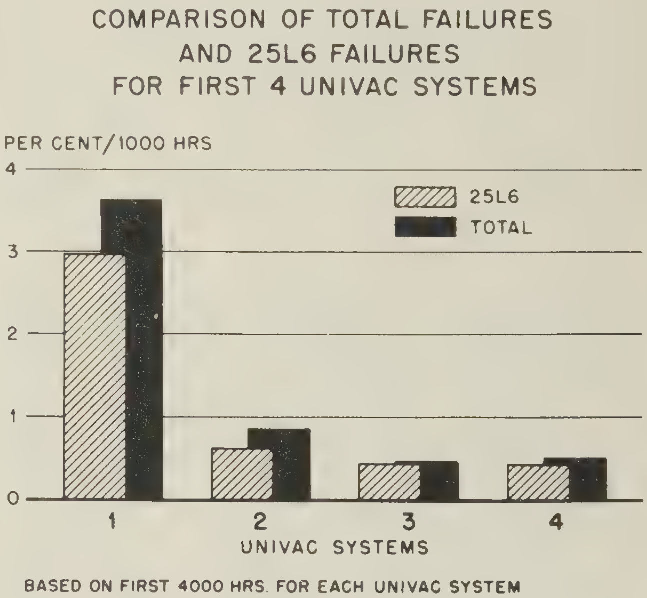

Fig. 4

CONCLUSION

Based on the performance record of tubes in the UNIVAC system, certain modifications in future tube programs can be suggested and are in the process of evaluation, but we believe that the basic approach will remain the same. Failure either to select a satisfactory computer tube or to design properly around the tube cannot be corrected by comprehensive inspection techniques or rigorous routine maintenance. The final goal of a high degree of tube reliability must rest on the satisfactory execution of each step in the program—selection, design, inspection, and maintenance. The rate of .1% operational failures per thousand hours testifies to the success of the UNIVAC tube program, and we believe

further refinement of inspection techniques and certain changes in the maintenance program will materially reduce this figure.

ACKNOWLEDGEMENT

The original analysis and preparation of data on the performance of tubes in the UNIVAC was done by Mr. Kraus. Mr. Hinkelman has extended this original work to include information on and evaluations of the later UNIVAC Systems. The authors wish to express their gratitude to Herman Lukoff who, with his staff, has been responsible for the maintenance of tube performance records, and for the solution of many of the technical problems related to the tube program. For their assistance in the preparation of this paper, we would like to thank Joseph D. Chapline, Andrew Bracy, Bernard Victor, Phyllis Blymire and others of the Eckert-Mauchly Division.

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From 1949 to 1952 Mr. Craig was a Member of the Technical Staff at the Hughes Aircraft Company Research and Development Laboratories, where he participated in the design and development of missile test and launch programming equipment. He also did research and design of components for analog computers and fundamental research in magnetic amplifiers. In 1952 he joined the Benson-Lehner Corporation, where he is now employed as research engineer for computer input-output and data reduction equipment.

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THOMAS D. HINKELMAN (A'52) was born in Williamsport, Pennsylvania, August 8, 1925. He received a BS degree from Rensselaer Polytechnic Institute in 1947 and an MBA from Harvard in 1948.

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REVIEW SECTION

It is the intention of this section to review articles that have been published since January 1, 1953 and to publish eventually reviews of all books of interest to those in the computer field. Articles dealing with electronic aspects of both analog and digital computers, as well as general expository articles, are to be included. All articles and books reviewed are numbered sequentially for each year; where known, the Universal Decimal Classification number is also given. The editors wish to express their gratitude to the reviewers who, through their efforts, make this section possible.

H. D. Huskey, Editor.

GENERAL

53-1

Fundamental Characteristics of Dig-l and Analog Units—J. M. Salzer. *Radio-Electronic Eng.* Edition of *Radio nd Telev. News*, vol. 49, pp. 13-15,30; ebruary, 1953.) This is a general in-rest article which discusses the ques-on of digital vs. analog as relates to omputers. It is stated that these terms e not adequate to fully describe a omputer. The author proposes three ore fundamental properties to be used r classifying equipment. These are:) positional notation, (2) quantization, nd (3) sampling. A pure digital com-uter would incorporate all three; a pure nalog, none. The three properties are scussed in some detail. It was con-ncluded that an understanding of these asic characteristics can help to orient ngineers in new avenues of endeavor. n example of this would be in the crea-on of special purpose devices utilizing oth digital and analog techniques.

D. E. Hart

53-2

Computing Machines in Aircraft En-ineering—C. R. Strang. *(Elec. Eng.*, ol. 72, pp.43-48; January, 1953.) An valuation of computing machinery is ven from the viewpoint of an aero-autical engineer. A brief history of the se of computing machinery at Douglas ircraft is given, describing the analog nd digital machines used, and the size the effort. The types of problems en-ountered are illustrated by two ex-mples, showing the need for a wide riety of mathematical techniques. The uthor points to a continuing need for oth analog and digital computers, and escribes the great value of the use of e computing facility. The machines' mitations are presented, together with ggestions to make them more useful to e aircraft industry.

Harry Larson

53-3

Designing for Maximum Reliability Panel Discussion)—H. T. Larson, J. J. onnolly, H. D. Huskey, R. Lusser, R. awlins, and W. A. Farrand. *(Proc. lectronic Computer Symp., April 30, ay 1, 2, 1952, Los Angeles, Calif.*, . VIII: 1-33.) Drawing from experience gained on the American Airlines reservations computer, J. Connolly discusses computer organization techniques designed to detect and signal the failure of a computer and to aid in the rapid location of a fault. He also describes briefly design techniques employed to minimize circuit failure. H. Huskey discusses desirable characteristics of vacuum tube pulse amplifiers used in computers. He further touches on such matters as heater potentials, regulation of voltages, temperature, and use of crystal diodes. Reference is made to experience gained on the NBS SWAC. R. Lusser presents charts and graphs showing the extremely high reliability required of the components of a complex device if its overall reliability is to be satisfactory. In connection with producing reliability in guided missiles and computers, he discusses such matters as specification of environmental conditions and tests-to-failure of all samples of all component types. R. Rawlins, drawing on experience gained in instrumentation of low level signals at high accelerations, discusses a variety of practical matters encountered in the use of vacuum tubes and circuit elements. W. Farrand discusses design philosophy and experience developed at his company in connection with building autonavigator computers. A transcription of questions from the audience with answers and discussion by panel members is included.

Harry T. Larson

53-4

Computer Reliability—E. S. Rich and R. R. Rathbone. *(Radio-Electronic Eng.* Edition of *Radio and Telev. News*, vol. 49, pp. 10-12,31; February 1953.) This article describes the results of a study made at the Massachusetts Institute of Technology into the matter of reliability of computer components and systems. Various types of failures are discussed. They include: (1) component failure, both total and marginal, (2) defects in construction which cause intermittent failures, e.g., poorly soldered joints, and (3) failures due to external noise. The use of marginal checking to locate potential errors is discussed. It is necessary to determine reliability of individual computer components and circuits before including them in a large computer system.

D. E. Hart

53-5

Some Techniques of Analog-to-Digital Conversion—Harry Burke, Jr. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.*, pp.XVII: 1-8.) This paper is a survey of analog-to-digital converters. It includes in chart form a concise classification of the known types of converters. The general characteristics of converters is described, with reference to accuracies obtained in actual systems. The paper is divided into sections of the major types. A description is given in each section of the various methods of obtaining that type of conversion. Although the description is brief, the survey is very complete in including the number of known systems of conversion.

Henry Doeleman

53-6

An Accurate Digital-Analog Function Generator—W. A. Farrand. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.*, pp.XVI: 1-9.) This paper describes a digital-to-analog converter in which the digital data is in the form of punched paper tape. The analog output is in the form of shaft position of any number of 1 to 4 shafts as described. The function is prepared on the tape. The paper tape is of the contact type output which selects proper circuits to a resistor matrix connected to a summing amplifier. The summing amplifier drives a servo system which positions the potentiometer as a function of the configuration on the tape. Since a motor is used to position the potentiometer, the device also provides shaft position as a function of the input information. The paper also describes methods of sequencing the data in a time-multiplexed form, which multiplies the accuracy of the output information by a factor approximately equal to the number of outputs. The system includes velocity information along with position data to improve response time of the servo system. This converter can provide a relatively high degree of accuracy.

Henry Doeleman

ANALOG COMPONENT RESEARCH

53-7

Different Approach to Analog Computation—C. R. Bonnell. *(Radio-Electronic Eng.* Edition of *Radio and Telev.*

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— The Editor

ews, vol. 49, pp.14–15,31; May, 1953.) n electromagnetic torsional integrating ıalog system is described, which comnes much of the speed of electronic ystems with the range and accuracy of echanical systems. The components of is system are precision torque generars and signal generators, amplifiers ıd fluid dampers. The theory of operaon of an analog computer based on ese components is outlined, and e operational formulas are tabuted. A demonstration model is decribed which can be operated openop or closed-loop. The results of ımple problems are shown. Other posble applications of the torsional ethod are mentioned, e.g., modulators, ervo-shaft positioners, and the utilizaon of residual torque as a memory sysm.

D. E. Hart

53-8

An Electro-Mechanical Multiplier for nalog Computer Application—Samuel . Dorsey. *(Proc. Electronic Computer ymp. April 30, May 1, 2, 1952, Los ngeles, Calif.* pp.V:1-7.) This paper escribes an analog multiplier which ill operate in four quadrants with a me constant in the vicinity of 0.1 econd. Accuracy of the prototype is out 3%, but the author claims that eatly increased accuracy can be obined by more precise construction. The art of the unit is a dual electrodynamoeter type wattmeter movement arranged that the two input signals excite the ssociated coils of one wattmeter secon. An amplifier amplifies the error gnal created by any movement of the haft. Shaft motion is detected by a ique error detection system. The nplified error signal is applied to one the coils of the second wattmeter oil, the other coil being excited with c. The amplified signal is applied in e proper phase to oppose the torque eated by the first wattmeter coil, and e amplified current is proportional to e product.

William L. Martin

ANALOG EQUIPMENT

53-9

The Benson-Lehner Photoformer—D. L. itman. *(Proc. Electronic Computer Symp. pril 30, May 1, 2, 1952, Los Angeles, alif.* pp.XV:1-4.) This paper describes ı arbitrary function generator employg a 16" TV type cathode ray tube. The notoformer is basically an arbitrary nction generator in which the input oltage determines the X position of the oot on a cathode ray tube. The Y voltge is determined by the shape of the ask on the face of the tube. The paper escribes the mechanical construction ıd facilities for changing the mask. The xplanation of the deflection circuits ıd amplifiers and frequency response quite complete. Diagrams illustrating the optical system and mechanical configuration are included.

Henry Doeleman

53-10

The Thermal Analyzer, A Special Purpose Computer—William L. Martin and Robert Bromberg. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.* pp.VI: 1-14.) This paper describes a special purpose analog computer designed to yield an approximate solution to problems of which transient heat flow in solids is typical. The analog is based upon the use of electrical resistors and capacitors to substitute for the components of an idealized lumped thermal circuit. The theory of the analog is presented with a description of the apparatus in operation at the Department of Engineering of the University of California at Los Angeles. Devices to make the computer more flexible are also described. A case is made for an economical special purpose computer which permits the operator to obtain a "feel" for his problem by varying some of the parameters and observing the effects on the system.

William L. Martin

UTILIZATION OF ANALOG EQUIPMENT

53-11

Analogue Computers for Feedback Control Systems—R. A. Bruns. *(Elec. Eng.* vol. 72, p.211; March, 1953.) (Digest of paper 52-247, AIEE Pacific General Meeting, Phoenix, Arizona, August 19-22, 1952; scheduled for publication in AIEE Trans., vol. 71, 1952.) This article gives a review of feedback control systems and shows how analog computers are useful in the synthesis of such systems. The present tendency in feedback control systems is to include the effects of saturation, irregularities of amplifying elements, and to utilize relay systems and nonlinear elements to better perform control functions. In the synthesis of control systems which do not lend themselves readily to straightforward theoretical approaches, electronic analog computer simulation is particularly useful. An example is given of the use of high speed relays, multiplying and dividing servomechanisms, and specially designed noise generators to instrument a complicated system.

Harry Larson

DIGITAL COMPONENT RESEARCH

53-12

How to Design Bistable Multivibrators—Ralph Pressman. *(Electronics,* vol. 26, pp. 164-168; April, 1953.) This article takes into account various factors which should be considered in the design of bistable multivibrators, or flip-flops, as they are more commonly known. The author presents equations for calculating the values of resistors and supply voltages necessary for a flip-flop, given a tube operating at a selected point on its characteristic curves. A design procedure is set forth and examples of flip-flop design, using a pair of pentodes in one case and a twin triode in another, are performed. The effect of the coupling capacitor in a flip-flop circuit and means for determining its proper size are discussed. Triggering networks and methods of triggering are discussed, and simplified circuits are shown. The effect various circuit components have upon the triggering rate is also noted.

Norman F. Loretz

621.318.572 53-13

Gated Decade Counter Requires No Feedback—E. L. Kemp. *(Electronics,* vol. 26, pp. 145-147; Feb., 1953.) This article discusses the advantages of a gated decade counter requiring no feedback over one requiring feedback. References are made to decade counters using feedback to achieve the decade count feature. A block diagram and simplified schematic are shown. A complete discussion of the operation of the counter is presented, including a timing chart showing input and output wave forms of the binaries and the gated amplifier. The gated amplifier is the part of the circuit which produces the decade action described. A complete schematic of a scaler with a scaling factor of 1,000 is shown. This decade circuit was designed and constructed for use in a scaler for counting particles in radioactive decay. However, the article presents information which would find use in digital computers also.

Norman F. Loretz

53-14

Ferrites Speed Digital Computers—David R. Brown and Ernst Albers-Schoenberg. *(Electronics,* vol. 26, pp. 146-149; April, 1953.) This article discusses the factors which must be considered in the choice of ferrite toroids for a coincident-current memory. The mechanics of storing binary information in a toroid, and typical characteristic curves of ferrite are presented. Desirable characteristics of ferrite for memory cores and other applications are mentioned. Constructional features of memory arrays and methods of switching, using ferrite toroids, are discussed and illustrated. Means of evaluating ferrite toroids for the memory application are presented and drawings of normal and disturbed output signals are shown. Finally, characteristics of the rectangular loop ferrite used at MIT in an experimental coincident-current memory, containing two 16 by 16 arrays, are presented, and some of the peculiarities encountered are discussed. A bibliography is given at the end of the article.

Norman F. Loretz

53-15

Saturable Reactors as Gates—B. Moffat. *(Quart. Repts. Computer Components*

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— *The Editor*

ellowship Mellon Inst., Quart. Rept. p. 9, Oct. 11, 1952, to June 10, 1953, p. IV, 1-12.) Easily saturated magnetic aterials are being investigated for ossible applications as high speed agnetic gates. The material must exbit low losses, a sharp saturation vel, and high incremental permeability remanence. The magnetic gate consists essentially of a transformer with ree windings, an input, an output, and control winding. If the core is saturated y the application of a dc current in the ontrol winding, no signal will be transmitted from the input to the output winding. When the control current is removed, e gate becomes an ordinary transformer. Due to the low loss requirement, only ferrites are being investigated at the present time. A number of ample toroids of several different ferites have been obtained. A magnetic est set up for making dc measurements f core characteristics has been completed, and some preliminary tests have een run. An experimental gate using wo small toroidal cores of Ferramic I" was constructed and qualitative bservations of its performance were ade.

F. A. Schwertz

53-16

Recent Developments in Transistor Electronics—W. Shockley. *(Proc. I.E.E. Pt. III, vol. 100, pp. 36-38; January, 1953.)* This article is a survey of a lecure by the author before the IEE. It is a semi-technical article which discusses transistor theory and application. t is good background reading for anyone not directly concerned with this ield. Three main points are emphasized:) Transistor action is now understood; he theory is well developed, 2) There re many forms of transistors, 3) Progress is being made in transistor manuacturing techniques. The theory of oles and electrons is discussed, and he theory of point contact and junction ransistors is developed. Mention is nade of power consumption and characeristic curves for circuit design.

D. E. Hart

53-17

Nonlinear Semiconductor Resistors—F. A. Schwertz and J. J. Mazenko. *(Quart. Repts. Computer Components Fellowship Mellon Inst., Quart. Rept. no. 9, Oct. 11, 1952, to June 10, 1953, pp. II, 1-20.)* A phenomenological theory for he nonlinear voltage-current characeristic curve displayed by a granular ggregate of silicon carbide is presented. The theory, which should apply to granlar semiconductors other than silicon arbide, is based on a very simple model f the aggregate, and on the assumption hat the essential resistance is located t the grain-grain contacts, the impedance of the bulk material being considered negligibly small. The current, i, is related to the voltage, V, by the equation

$$i = \frac{kAP^{n/m}d^{n-2}V^n}{t^n}$$

where A is the cross-sectional area of the aggregate, t, the thickness, P, the applied pressure, and d, the average particle diameter. The constants k, n and m are structure-sensitive, that is, they depend on the physical-chemical nature of the particles forming the aggregate. Factors influencing the values of these constants include impurity concentration in the semiconductor, elastic constants, and particle shape. The validity of this equation is supported by careful measurements made on granular aggregates of silicon carbide.

F. A. Schwertz

53-18

Nonlinear Resistors in Logical Switching Circuits—F. A. Schwertz and R. T. Steinback. *(Quart. Repts. Computer Components Fellowship Mellon Inst., Quart. Rept. no. 9, Oct. 11, 1952, to June 10, 1953, pp. I, 1-15.)* Nonlinear resistors may be used to replace whole arrays of crystal rectifiers in certain logical switching circuits. Where such replacement is possible, considerable savings in fabrication and component costs are effected, because both the nonlinear resistors and the associated connecting busses are made by applying printed circuit techniques to standard plastic – or ceramic-bonded sheets of semiconductors such as silicon carbide. A binary-to-octal converter and a three-binary-digit adder fabricated according to the above-described method are used to illustrate the technique.

F. A. Schwertz

53-19

Bistable Optical Elements—A. Milch. *(Quart. Repts. Computer Components Fellowship Mellon Inst., Quart. Rept. no. 9, Oct. 11, 1952, to June 10, 1953, pp. III, 1-19 + figs.)* A bistable phototube that can store digital information requires the presence of an active phosphor and a photoemissive alkali metal in the same tube. The deposition of these surfaces, separately and together, has been studied. The problems of optimum conditions for maximum activity and the effect of interaction of the two materials when in the same tube have received detailed analysis. The study of the chromotropic material Ag_2HgI_4-Cu_2HgI_4 has been extended. It appears possible that it may find use not only in storage of digital information, but also in high speed printing.

F. A. Schwertz

53-20

Utilization of Germanium Diodes (Panel Discussion)—L. L. Kilpatrick, N. Bell, L. S. Pelfrey, W. Speer, J. H. Wright, and A. S. Zukin. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif., pp. VII: 1-27.)* A transcription of a panel discussion on the utilization of germanium diodes as applied to the design of electronic digital computers is presented. A brief description of the diode circuitry employed by the various companies represented is followed by a discussion of diode characteristics, factors influencing reliability, and circuit design philosophy. Questions from the audience with answers given by panel members are included.

Lester L. Kilpatrick

DIGITAL SYSTEMS RESEARCH

53-21

Automatic Program Control Utilizing a Variable Reference for Addressing—A. S. Zukin. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif., pp. XIII: 1-6.)* It has been standard practice in computers with serial memories to use an arbitrary reference pulse from which word times are counted for memory access. This necessitates two registers and a comparison device, unless one is willing to wait until the end of a cycle before starting to look for a word. In the latter case only one register is necessary. The author proposes a variable reference system, in which the reference is the time at which the previous operation was concluded, and the address required is given as the number of word times since the conclusion of the last action. This system utilizes only one register, at no sacrifice in speed. Other advantages cited are the facts that fewer digits are needed to specify addresses and a check on the coder's addressing is provided.

Roselyn Lipkis

DIGITAL EQUIPMENT

53-22

The Electronic Discrete Variable Computer—S. E. Gluck. *(Elec. Eng., vol. 72, pp. 159-162; February, 1953.)* This article presents a general description of the EDVAC, a large-scale digital computer designed and constructed by the Moore School for Army Ordnance. The logical structure is stated in general terms, followed by a discussion of binary and octal number representation and order representation. A block diagram of the major units is presented, along with a brief description of each of these units. Finally, the present operating status of the EDVAC and contemplated additions to the machine are stated.

Harry Larson

53-23

Automatic Cruise-Control Computer for Long-Range Aircraft—J. R. Shull. *(Elec. Eng., vol. 72, pp. 309-312; April, 1953.)* At present, aircraft power settings

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r maximum endurance or maximum nge are controlled manually by refer-ng to various charts. These charts do t include provision for abnormal flying nditions, such as icing, which can rkedly alter the proper power settings. he author proposes a computer which ntinuously monitors air-speed and el flow signals, computing their ratio the range parameter—miles per pound. dditional equipment is proposed which auses the system to move to a point here the range parameter is optimized, d to oscillate slowly about this operat-g point. (This paper also appeared in e first issue of the *I.R.E. PGEC Trans-tions*, PGEC-1, pp. 47-51; Dec., 1952.)

Harry Larson

53-24

The XY Toll Ticketing System—H. L. oote. *(Elec. Eng.*, vol. 72, pp. 517-522; ne, 1953.) The system described here tomatically records appropriate in-rmation when a telephone call is made, riodically reads this information into pecial purpose computing circuitry, and ints a "toll ticket" for each call made. recorder-reproducer associated with ach trunk records on magnetic tape oused in a small tank similar to the the NBS "wastebasket." Counting hains and rings in the computer are uilt around cold-cathode tubes. Gen-al descriptions are given of the re-order-reproducer, magnetic head, switch-g circuits, and printer. Provisions for andling exceptional situations, such as verly long calls or heavily loaded unks, are described.

Harry Larson

53-25

Garment Tag Equipment—Orville G. essler. *(Review of Input and Output quipment Used in Computing Systems, apers and Discussion Presented at the oint AIEE-IRE-ACM Computer Confer-nce, New York, N. Y. Dec. 10-12, 1952*, p. 122-125; March, 1953.) For purposes f continuous inventory control, Sears, oebuck & Company required a system of uplicate, but joined, printed and punched ards to serve as price tags on individual ems of merchandise (in this case gar-ents, garment-merchandising activities aving served for developmental work). ince the normal punched card was too arge for effective use on small items, quipment to print and punch a much maller card (2 1/4 by 2 7/8 inches) was eveloped jointly by the A. Kimball ompany and the Karl J. Braun Engineer-ng Company, Inc. When a sale is made, ne of the duplicate halves of the tag is etached and forwarded to fulfill its asic purpose of inventory control. Small ots of cards may be sorted manually; ots of any size are sorted at the rate of 00 per minute by a photoelectric tag eader developed by the Potter Instru-ent Company, Inc. The tag reader is onnected to a reproducing punch hich punches standard cards for pro-essing in business machines.

John B. Bennett

53-26

Electronic Addressing Aids Publishers—John M. Carrol. *(Electronics*, vol. 26, pp. 98-100; February, 1953.) This article describes an address printing machine developed by the Eastman Kodak Company. The machine is used to print labels for the large mailing lists of various departments of Eastman Kodak. The printer obtains address information from punched cards and is capable of printing 42,000 four-line address labels per hour. Both mechanical and electronic features of the machine are discussed and the method of storing the address information on punched cards is illustrated. Existing and proposed methods of accomplishing the tremendous job of address printing are mentioned and briefly discussed. A list of references to high speed printers is presented at the end of the article.

Norman F. Loretz

53-27

Survey of Mechanical Printers—J. C. Hosken. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N. Y., December 10-12, 1952*, pp. 106-112; March, 1953.) Defining mechanical printers for computer use as those in which "something solid hits a piece of paper to transfer ink to it," the author finds that current developments in this field fall into five general categories. Each category is described (and illustrated) in some detail, and examples of the equipment presently available are cited. Briefly, the author finds that mechanical printers now (or soon to be) in production are the single-action typewriter (Flexo-writer); the line-at-a-time printer (IBM, Remington Rand, and Bull tabulators and ERA printer); the on-the-fly printer with continuously revolving type wheels (ANelex and Shepard printers and the Potter "flying typewriter"); the matrix printer (IBM printing punch type *26* and Eastman Kodak printer); and the bar and helix printer (Eastman Kodak printer manufactured Addressograph-Multigraph).

John B. Bennett

53-28

The Eastman Kodak Multiple-Stylus Electronic Printer—R. G. Thompson, and C. E. Hunt, Jr. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N.Y., December 10-12, 1952*, pp. 118-122; March, 1953.) A nonphotographic electromechanical printer, the Eastman Kodak unit prints the output of an electronic computer, dick strip for addresses, and so forth. In use, a coded signal from a computer or from film, punched cards, tape, etc. releases an established sequence of operations which prints the desired character from a 7 x 5 array of 35 dots. Each character in the font is permanently connected into a 35-switch electronic matrix printing storage which operates the single row of 5 or 7 printing styluses. These latter print, through one-time carbon paper, on ordinary paper in rolls of any desired width and 4,200 feet in length. Printing speed is 300 to 400 characters per second for each printing head; the number of heads can apparently be increased as desired. The major components, printer and electronic unit, and the operation of this unit are described in detail and illustrated.

John B. Bennett

53-29

Nonmechanical High-Speed Printers—R. J. Rossheim, *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N. Y.,Dec. 10-12, 1952*, pp. 113-117; March, 1953.) Limitations on speed inherent in mechanical printing may be overcome by essentially nonmechanical methods (notwithstanding the problems of character selection, positioning, and formation, and of recording the character when formed). Several systems fall into the nonmechanical category, and the characteristics of each are described in detail. The Dataprinter (Atomic Instrument Co.) gives a dot-array presentation of 3-digit decimal numbers in a column at rates of from 10 to 500 per second. General Electric's process of Ferromagnetography (although not yet adapted to digital-computer output) has a speed of 40 single-character, single-column lines per second. The Magnetic Numeriscope (ERA) with a full complement of equipment gives an output of up to 8,000 characters per second. A more radical approach to character display is Consolidated Vultee's Charactron in combination with the Xerographic reproduction process of the Haloid Co. Nonmechanical printers are also in the developmental stages at the Austin Co. and Hogan Laboratories, Inc.

John B. Bennett

53-30

Punched Card to Magnetic Tape Converter for UNIVAC—E. Blumenthal and F. Lopez. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N.Y., Dec. 10-12, 1952*, pp. 8-11; March, 1953.) The punched card to magnetic tape converter consists of a card-feed capable of feeding punched business machine cards at a rate of 354 cards per minute, a suitable decoding network for changing the punched card code into the UNIVAC code and a tape handling mechanism which automatically advances the tape as recording is made on it. The cards are fed endwise on to an openwork drum, and they are read photoelectrically row by row by an assembly of twelve photocells. Considerable attention was given to accurate reading of off-punched cards and a checking circuit is included

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hich checks for mispunched cards and eports a mispunched symbol on the ape which may be later picked up by e UNIVAC.

T. H. Bonn

53-31

Input Devices—L. D. Wilson and E. oggenstein. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented t the Joint AIEE-IRE-ACM Computer onference, New York, N.Y., Dec. 10-12, 952*, pp. 53-58; March, 1953.) The Uniyper is a device for preparing tapes for he UNIVAC System from a typewriter. he machine consist of a keyboard very imilar to the standard typewriter keyoard, a punched paper for performing utomatically certain functions, and a ape transport mechanism for advancing utomatically the magnetic tape and reording blocks of information. The deice contains a provision for erasing alsely typed information. The tape can e back-spaced one character at a time. he punched paper tape keeps track of he typist's position in a block and can ill out a block with "ignore" signals utomatically if the typist's information oes not complete the block. Encording he information from the keyboard to the tandard UNIVAC code is performed by a esistor encoder. Various interlocks are sed to force the typist to use the corect format for the UNIVAC.

T. H. Bonn

53-32

The Uniservo-Tape Reader and Reorder—H. F. Welsh and H. Lukoff. *(Review of Input and Output Equipment Used n Computing Systems, Papers and Discussions Presented at the Joint AIEE-RE-ACM Computer Conference, New ork, N.Y., Dec. 10-12, 1952*, pp. 47-53; larch 1953.) The Uniservo is the high peed magnetic tape input-output device or the UNIVAC. The tape speed is 120 nches per second and the pulse density s 100 pulses per inch, resulting in an nstantaneous conversion rate of 12,000 lphabetic symbols or digits per second. omputing continues simultaneously with nput or output operations. Up to ten Iniservos can be connected to one JNIVAC. Starting and stopping time in he Uniservo is ten milliseconds. An nusual feature of the Uniservo is the se of a plastic spacer between the agnetic reading and recording head and he metal tape to reduce friction between he head and tape and reduce wear. Bad pots in the tape are found by a preiminary inspection procedure and holes unched in the tape on either side of the ad spots. Holes are sensed photolectrically and the space between holes s automatically skipped by the Uniservo. Details of the problems involved in conecting a large number of Uniservos into ne common system, details of the signalo-noise ratio obtained, and of the control nd tape transport are included in the aper.

T. H. Bonn

53-33

Output Devices—E. Masterson and L. D. Wilson. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N.Y., Dec. 10-12, 1952*, pp. 58-61; March, 1953.) The output devices are the Uniprinter, a magnetic tape operated typewriter, and a high speed printer. The high speed printer is still under development. The Unityper operates at a speed of ten to twelve characters per second and utilizes standard continuous form pinfeed paper. A standard Remington Rand electric typewriter is used with an actuator under each key. Information is recorded at a pulse density of twenty per inch by the Uniservo for tapes which are to be used on the Uniprinter. The tape transport mechanism of the printer starts the tape before each pulse and stops it between pulses. Editing information can be included in the UNIVAC program so that any desired format which can be accomplished on a typewriter can be obtained automatically on the Unityper. The high speed printer will be able to use preprinted forms, will make carbon copies, and it will have the paper feed under the control of a punched paper loop so that paper can be advanced rapidly over areas where no printing occurs. The minimum speed of the printer will be 200 lines a minute, each line containing 120 characters.

T. H. Bonn

681.142:621.383 53-34

Intermittent-Feed Computer-Tape Reader—B. G. Welby. *(Electronics*, vol. 26, pp. 115-117; February, 1953.) An intermittent-feed tape reader has been developed by Ferranti Ltd., an English concern. The unit described in this article was built for use in the input system of the Ferranti Digital Computer (Mark I). The reader operates on the photo-electric principle while reading teleprinter punched tape at a top speed of 200 characters per second. The article describes the mechanical features necessary for the rapid tape positioning achieved. Some of the electronic circuits are presented and discussed and a block diagram of the electronic control system for tape feed is shown. (See 53-35 of this issue.)

Norman F. Loretz

53-35

The Input-Output System of the Ferranti Universal Digital Computer—D. J. P. Byrd and B. G. Welby. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N. Y., Dec. 10-12, 1952*, pp. 126-132; March, 1953.) The input-output device developed by Ferranti Ltd. is a part of the engineered Universal Digital Computer now under construction. The initial decision was to use tape for input-output but to develop improved methods of processing. The complete in-out system will include a high-speed tape reader, an output system, and a high-speed printer. (The new reader and its associated equipment was installed with the present computer at Manchester University where it has operated successfully for 18 months.) The tape reader comprises an optical projection system for reading, photoelectric-cell amplifiers, a tape-feed mechanism, electromagnetic brakes, and an input control system. The output includes a teleprinter, a tape punch, and a check circuit (which indicates discrepancies between the mechanical setting of an electromagnet and the electric potentials defining the condition required). The printer, developed for coordination with existing punched-card systems, consists of a print console, power supply, and circuitry pillar; it is capable of 150 lines (of 62 characters) per minute. (See 53-34 of this issue.)

John B. Bennett

53-36

The Teleplotter, A Digital Plotting Device—Donald F. Belloff. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.* pp. XVIII:1-7.) This paper describes a plotting device manufactured by the Telecomputing Corporation. It receives information in the form of digital X and Y point coordinates. Information enters the plotter through the use of a manual keyboard or through the use of an IBM card reader. It plots approximately fifty points per minute on a surface area of 650 x 1400 millimeters. The system design is described in detail. The equipment can also be used to read plotted information providing a digital output as a function of the plotted data. Data processing methods are explained in detail.

Henry Doeleman

53-37

A Numerically Controlled Milling Machine—J. C. McDonough and A. W. Susskind. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N. Y. Dec. 10-12, 1952*, pp. 133-137; March, 1953.) A numerically controlled milling machine is now in operation at the Massachusetts Institute of Technology Servomechanisms Laboratory. In the operation of this machine, instructions from punched paper tape prescribe the movement of the tool in a straight line from one specified point to another (and prescribe the specified time interval). The straight lines are generated by a combination of the orthogonal motions of the table, the head, and the cross slide. These components are controlled by three pulse trains originating in the pulse generator, routed through the pulse distributor, and interpreted for milling-machine use by a decoding servomechanism. Programming for the M.I.T. machine

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cludes "determination of the desired ol path over the work, reduction of at path to incremental straight-line gments, numerical specification of e end points of the segments, transla- on of the specification into a form ich can be punched on paper tape, and, ally, perforation of the tape."

John B. Bennett

UTILIZATION OF DIGITAL EQUIPMENT

53-38

UNIVAC on Election Night—A. F. aper. *(Elec. Eng.,* vol. 72, pp. 291- 93; April, 1953.) A discussion of NIVAC's role in predicting the na- onal election results is presented. A ief, non-technical description of the atistical prediction technique is given. e accurate prediction UNIVAC pro- ced on the basis of early returns is scribed.

Harry Larson

53-39

Some General Precepts for Program- ers—Everett C. Yowell. *(Proc. Elec- nic Computer Symp., April 30, May 1, 1952, Los Angeles, Calif.,* pp. X:1-6.) e author illustrates and elaborates on e following six precepts for program- ers: "(1) A programmer should include his routines a judicious selection of ecks to detect machine failures; (2) A ogrammer should include whatever ecks he can find to detect errors in e coding of the problem; (3) A pro- ammer can at times be of great assis- nce to the maintenance engineer in agnosing machine errors, and hence ould be available if his assistance is quested; (4) A programmer should not low his coders to spend too much time striving for elegance of coding when egance is not needed; (5) A programmer ould devote as much of his time as ems appropriate to finding the most ficient method of solving a problem;) A programmer should consider care- lly the problem at hand before choosing ther a floating decimal or a fixed deci- al arithmetic system."

Roselyn Lipkis

53-40

Programming for On-Line Computa- ons—Harold Luxenberg. *(Proc. Elec- nic Computer Symp., April 30, May 1, 1952, Los Angeles, Calif.* pp. XI:1-6.) e problem of tracking a target through ree-dimensional space with Raydist uipment is discussed as a typical -line, or real-time, computation. Here mputation time must be minimized, in der to achieve a high data sampling te, and it is desirable that the pro- am be self-correcting after a period erratic or missing data. Several ethods of solution are described and aluated in terms of the requirements hand. It is shown that a change in e coordinate system simplifies the oblem and makes possible a stable lution.

Roselyn Lipkis

53-41

An Approach to the Use of the IBM Card-Programmed Electronic Calculator in the Solution of Engineering Problems —Murray L. Lesser. *(Proc. Electronic Computer Symp., April 30, May 1, 2, Los Angeles, Calif.,* pp. IX:1-7.) A description is given of the IBM Card-Programmed Electronic Computer (CPC), with a discussion of its adaptability to the solution of engineering problems. Two general operating techniques are described; (1) the use of general-purpose plug-boards, by means of which the CPC is made to resemble a large-scale automatic computer; and (2) the arrangement of the CPC components to handle specific problems or classes of problems in the most efficient manner. The author points out the advantages in the second technique in efficiency and in challenge to personnel. He recognizes the necessity for highly-skilled personnel in this system, and recommends the utilization of computer engineers, as opposed to machine operators or mathematicians, for problem solution.

Roselyn Lipkis

53-42

Programming for Finding the Characteristic Values of Mathieu's Differential Equation and Spheroidal Wave Equations—Gertrude Blanch. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.,* pp. XIV: 1-30.) This paper is a description of the procedures used in computing the characteristic values of Mathieu's differential equation

$$y'' + (b - s\cos^2 x)y = 0$$

on the SEAC. A statement is given of the background of the problem, and a detailed mathematical appendix is included which covers the theory associated with the problem, the scaling, the steps of the program, and the error checks. Of special interest to programmers is the description of the possible pitfalls in the computation, and the methods used to overcome them.

Roselyn Lipkis

ORIENTATION READING

53-43

Computers—Past, Present, and Future —W. H. MacWilliams, Jr. *(Elec. Eng.,* vol. 72, pp. 116-121; February, 1953.) This article deals first with the progress made in computer development during the past century. Present digital and analog machines are then discussed and compared. Current computer problems and trends are presented. The author then proceeds to give probable future trends concerning the structure of computers and the functions of these machines. The development of computing machinery is presented as a new aspect of the industrial revolution. Machines are able to take over boring, burdensome jobs, thereby raising the intellectual level of men's jobs as well as increasing the material wealth and providing more time for activities not immediately concerned with earning a living.

Harry Larson

53-44

Summary and Forecast—Samuel N. Alexander. *(Review of Input and Output Equipment Used in Computing Systems, Papers and Discussions Presented at the Joint AIEE-IRE-ACM Computer Conference, New York, N.Y., December 10-12, 1952,* pp. 137-139; March, 1953.) Speedy attainment of computer efficiency outstripped comparable advances in the development of input-output devices. Recognizing the need for like degrees of speed and efficiency in all elements of the complete system, the Joint Computer Conference was devoted to a survey of the characteristics of a representative section of in-out equipment already in use and for which operational experience is available. In addition, a part of the program surveyed a few areas of application for information-processing machinery. A second industrial revolution is predicted as electronic information-processing machinery is generally applied to office procedures and as the full advantages of such machinery are understood and realized. The author sees a further application of data-processing equipment in prediction calculations involving continuing contact with the real world.

John B. Bennett

53-45

The Human Computer's Dreams of the Future—Ida I. Rhodes. *(Proc. Electronic Computer Symp., April 30, May 1, 2, 1952, Los Angeles, Calif.* pp. XII:1-5.) The requirements for a small, inexpensive calculator are listed as follows: (1) internal access time of 600 microseconds per 50-bit word, (2) ratio of external to internal access time of 25 to 1, (3) four-address code, (4) command list including addition with branching of command after overflow, discrimination, high- and low-order multiplication, unrounded division, logical transfer, shift, input-output, and breakpoint and absolute stop, (5) portability, and (6) decimal arithmetic operations. The author also expresses her hopes for great engineering advances in the future in the development of facilities for rapid automatic bookkeeping procedures for immense masses of data, and describes a hypothetical insurance company with such facilities.

Roselyn Lipkis

BOOK REVIEWS

53-46

Advances in Electronics—L. Marton, Ed. (Academic Press, Inc., New York, Vol. IV, x + 344 pp., Illus.; 1952.) This is the fourth volume of a series of papers concerned with physical electronics and

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the principal components of electronic devices. In this volume there are seven papers, one of them by C. V. L. Smith, who discusses electronic digital computers. "Alas, there is no bibliography, but the reader is referred to another treatise on the same subject. After a general introduction dealing with the principles involved in the planning of an electronic computer, the author describes in detail the Whirlwind and SEAC computers, which are now operating satisfactorily. Apart from the omission of references, this contribution is one of the best and most instructive in the volume."

From a review in *The Scientific Monthly*. D. ter Haar

53-47

Electronic Analog Computers—G. A. Korn and Theresa M. Korn, (McGraw-Hill Book Co., New York, xv + 378 pp; 1952.) It has become stylish since the end of World War II to expend a lot of time, money, and effort on large-scale computers. This has been accomplished by much publicity in magazines, newspapers, and in lectures. Extravagant claims have been the rule, and expressions such as "a machine to replace the human brain" have been commonplace. When such a movement gets under way, it is important that a survey of accomplishments be made from time to time so that the scientific public can evaluate the actual situation.

Two major types of computers have appeared during this post-war period: digital and analog. Whereas the first type has motivated most of the publicity and has clothed itself with an air of glamour, the second has become the unglamorous workhorse of the trade. Several lines of dependable computers, mostly developed under military contracts, are now commercially available, and many computing centers exist which are devoted to the solution of scientific and engineering problems. Authors have made a significant contribution in surveying the analog devices available and the theory upon which they operate. The analog-computing field is a rapidly expanding one, with new developments appearing frequently. Hence the book must be viewed as a status report as of the date it was presented to the publisher, say late 1951.

The modern analog computer is a natural outgrowth of the mechanical differential analyzer as described by Bush and Caldwell, who established the computing philosophy of such devices, and the rapid development of feedback principles during the war years. The end result has been the development of analog computers which are quite versatile, relatively cheap, and largely electronic. These devices solve sets of simultaneous ordinary differential equations which may be either linear or non-linear. These computers are not efficient in solving either partial differential equations or statistical problems.

The book divides itself naturally into two major parts. The first three chapters constitute the first part and cover the philosophy of analog computing, operating procedures, and typical problems. The second part, consisting of five chapters, is devoted to the technical problem of building computing components and their integration into a general purpose computer. The first part is straightforward, for one of the beauties of analog computing is that the basic principles are essentially simple.

Authors have done an excellent job in discussing devices and systems which have appeared to date. A reasonable division has been made between slow and repetitive computers, and their good and bad points accurately compared. They have pointed out the general accuracy, dependability, and flexibility of operational amplifiers, but have not glossed over the relative unsatisfactory performances of multipliers and function generators. In short, the book is a must for anyone who contemplates the purchase or the development of an analog computer. It clearly points out the best techniques which have appeared and can thus save a designer from making many false starts. Numerous references are given so that the interested reader can pursue any special topic more thoroughly.

To a reader interested in analog computing in the broad sense, the lack of any reference to network computers may come as a disappointment. The authors have chosen to limit their book to dc analog computers, and in this they are perhaps wise, for the philosophy, operation, and design of network computers are so different that their inclusion would make the book too long.

Courtesy of *Applied Mechanics Reviews*. H. M. Trent

518.5 53-48

Giant Brains—E. C. Berkeley. (John Wiley and Sons, New York; Chapman and Hall, London, 1949, xvi + 270 pp., Illus.) The principles of coding information and the binary system of notation are discussed, and the various types of punched-card machines described. Chapters are then devoted to each of the following representative calculators: the Massachusetts Institute of Technology differential analyzer, the Harvard I.B.M. automatic sequence controlled calculator, the ENIAC, the Bell Laboratories' general-purpose relay calculator, and the Kalin-Burkhart logical-truth calculator. The operation of all are fully described, but without circuit or constructional details. Future designs are mentioned, including such possibilities as automatic translators, typists and information machines. Some of the social implications of the robot are touched upon. There is a list of more than 250 references. The book is intended to be understandable by non-specialists.

Courtesy of *Science Abstracts*.

53-49

Mathematical Machines and Instruments (Mathematische Maschinen und Instrumente)—F. A. Willers. Akademie-Verlag, Berlin, xii + 318 pp.; 1951.) Part of this book constitutes a very complete treatise on slide rules, planimeters, hodographs, harmonic analyzers, and other small instruments for carrying out mathematical operations. The remainder contains a very incomplete description of the modern automatic digital computing machines.

Essentially, this is a revised edition of *Mathematical Instruments* by the same author, published in 1943. The change in title is meant to indicate the increased importance to which digital machines have grown in recent years. (The author uses the word *machines* for digital computers, *instruments* for analog computers.) In further recognition of this growth, a good deal of material on digital machines, especially the large automatic ones, has been added. But recent developments in the digital field have been so rapid that it would have been impossible to treat them in as much detail as the older subjects, without doubling or trebling the size of the book. The result is a strangely heterogeneous work. As far as the small instruments mentioned above are concerned, the book contains all the information anyone could desire, while the treatment of the large digital machines is so meager and so out of date that it can be used at most as a preliminary introduction to the subject, and even for that purpose, other books are better suited. There is a good chapter on desk-type calculators; understandably, it deals mostly with European makes, but this limitation is not serious, as the differences between American and European machines are not significant. There is also an adequate description of differential analyzers of the Vannevar Bush type, but the electronic differential analyzers, which today are far more widely used, are hardly mentioned. No mention at all is made of the various special-purpose machines such as linear-equation solvers.

Courtesy of *Applied Mechanics Reviews*. F. A. Alt

518.5:621-52:621.318.572 53-50

Synthesis of Electronic Computing and Control Circuits—Staff of the Computation Lab., Harvard Univ. (*Ann. Comput. Lab., Harvard Univ.*, vol. XXVII. Harvard University Press, Cambridge, Mass.; Geoffrey Cumberlege, London, 278 pp.; 1951.) The book investigates the functional behavior of electronic control circuits and develops an algebraic analysis based on a binary function of binary variables—the switching function. The mathematical

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methods with which the book is concerned cover procedures for (1) transforming functions from canonical form to those having a minimum number of variable occurrences, and (2) converting minimal forms into valve operators. Essentially, the design process consists of this sequence: mathematical expression of the problem, switching function expression, valve-operator expression, symbolic circuit, schematic and hence final circuit. The elaboration of symbolic circuits, the derivation of their describing expressions, and the formal rules of manipulation are initially treated in consideration of the 2- and 3-variable problem and thence that of n variables. A chart for the derivation of minimal forms for functions of four variables is given, together with rules, and discussed in relation to symbolic circuits which are classified with regard to the means by which their output voltage is delivered. Minimizing charts are quoted. Pyramid and rectangle multiple-output circuits are specially treated, which lead to the general multiple-output case. Problems peculiar to trigger circuit analysis are indicated and those circuits adapted to the general treatment are defined. Ring and digit counters are thus analysed, and 5-variable charts drawn up to provide the required minimal expressions. The introduction of time variables does not affect the general mathematical procedure which is well suited for circuits involving, e.g., gating voltages or advancing pulses. The technique is developed to handle the operation of units of electronic digital computers: rectifiers, coders (the minimal circuit is here derived for a given coding system), adders and accumulators, and multipliers. Examples of design problems, mainly computing, are worked out in all sections to demonstrate the methods and their field of application. The selection of these examples, and the symbolic circuits associated with them, are representative and excellently presented. Tables of input inversions, input rearrangements, and switching functions, all for four variables, are appended, and their use explained.

Courtesy of *Science Abstracts.*

A. J. Kennedy

INSTITUTIONAL LISTINGS

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590 Madison Ave., New York, N. Y.

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Technical Computing Bureaus

LIBRASCOPE INCORPORATED
1607 Flower Street, Glendale 1, California

Analog and Digital Computers for
Industrial Application; Analog Components

MAGNETICS RESEARCH COMPANY
142 King Street, Chappaqua, New York

Magnetic Shift Registers, Magnetic Switching Systems,
Pulse Transformers

MID-CENTURY INSTRUMATIC CORP.
611 Broadway, New York 12, N. Y.

Analog Computers - Electronic Function
Generators - Recorders - Servomechanisms

THE J. M. NEY COMPANY
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Precious Metals including Contacts, Slip Rings,
Assemblies, Fine Resistance Wire

GEORGE A. PHILBRICK RESEARCHES, INC.
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Mathematical or Dynamic Applications

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Flying Typewriter, Random Access Memory,
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Computer Components, Computing Service,
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Electronic Analog Computers - Servomechanism
Components - Resolvers - Gyros - Gears

TECHNITROL ENGINEERING COMPANY
2751 No. Fourth St., Philadelphia 33, Pa.

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Pulse Transformers, Delay Lines

TELECOMPUTING CORPORATION
133 E. Santa Anita, Burbank, California

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Development - Data Handling and Inventory Systems -
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